APPENDIX B

CALCULATIONS

BOD Removal in Ponds

$$\frac{C_n}{C_o} = \frac{1}{1+(k/nt)^n}$$ First order for *n* equally sized lagoons in series (ref. M&E p 843)

$$C = \frac{C_o}{1+(kV/Q)}$$ First order for each lagoon with unique volume and/ or removal rate (ref. M&E p 843)

Effluent BOD_5 Goal

C = 80 mg/L* (conserv. assumption of 80% of eff. Limitation)

Infflient BOD_5

C_o = 360 mg/ L (Sept06 - Aug08 90th percentile BOD_5)
Estimated Inf. BOD_u = 529.2 mg/ L (inf. BOD_5 x 1.47)

$k_T = k_{20}(1.036)^{T-20}$

k_{20} =	0.276	d^{-1} (first-order rate constant at 20°C)		
T_L =	49.4	°F (Approximate ground temp., Dec)		
=	9.7	°C	=	282.8 °K
T_H =	71.5	°F (Approximate ground temp., July)		
=	21.9	°C	=	295.1 °K
k_L =	0.19	d^{-1}		
k_H =	0.30	d^{-1}		

Flows (current 2008)

Jan-08	0.638	mgd	= Q_H (Conservative flow)
Mar-08	0.57	mgd	= Q_L
Permitted MMF	0.900	mgd	= Q_{MMF}

Volumes

Primary	=	295,700	ft^3
	=	2,211,984	gallons

*Fraction of Secondary Ponds for clarification: 0

Secondary	=	417,300	ft^3 (total volume available for aeration)
	=	3,121,613	gallons

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Aeration requirement (oxygen demand)

O_2 demand (lb/ day) = Co x 1.5 x Q_{Ave} x 8.34e-6

Note: 1mg/L = 8.34e-6 lb/gal;

Calculated oxygen demands

Cu = 540 mg/ L (1.5 x Co)

Q_L = 570,000 gpd
Q_H = 638,000 gpd
Q_{MMF} = 900,000 gpd

Oxygen demand for low flow rate: **2,567.1 lb O_2/ day**
Oxygen demand for high flow rate: **2,873.3 lb O_2/ day**
Oxygen demand for permit MMFflow rate: **4,053.2 lb O_2/ day**

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Current System Aeration Capacity

Calculate actual oxygen transfer rate for low-speed surface aerators

$$N = N_o \times \frac{B\,C_W - C_l}{C_{S\,20}} \times 1.024^{T-20} \times a$$

N_o =	2.5	lb O_2/ HP.hr (O_2 transferred under std. cond. for low-speed surface)
B =	1	(salinity-surface tension factor, typically 1)
$C_{W\,L}$ =	11.0	mg/ L (oxygen saturation concentration at temp 9.7C and 300 ft, M&E)
$C_{W\,H}$ =	8.5	mg/ L (oxygen saturation concentration at temp 21.9C and 300 ft, M&E)
C_l =	2.0	mg/ L (operating oxygen concentration)
$C_{S\,20}$ =	9.08	mg/ L (oxygen saturation concentration at temp 20C)
T_L =	49.4	^oF (Approximate ground temp., Dec)
=	9.7	^oC
T_H =	71.5	^oF (Approximate ground temp., July)
=	21.9	^oC
a =	0.82	oxygen transfer correction factor for municipal wastewater
N_L =	**1.95**	**lb O_2/ HP.hr (low temp)**
N_H =	**2.01**	**lb O_2/ HP.hr (high temp)**
Available HP =	110	HP (for surface aerators)
$AOTR_L$ =	**5140.8**	**lb O_2/ day (low temp)**
$AOTR_H$ =	**5295.8**	**lb O_2/ day (high temp)**

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Four Ponds in Series - Winter Season (Low temp & low flow condition)

Pond #1	V_1 =	2,211,984	gallons
	Q =	570,000	gpd
	k_L =	0.19	d^{-1}
	t =	3.88	days
	C_o =	360	mg/L
	C_1 =	206.5	mg/ L
Pond #2	V_2 =	2,211,984	gallons
	Q =	570,000	gpd
	k_L =	0.19	d^{-1}
	t =	3.88	days
	C_1 =	206.5	mg/ L
	C_2 =	118.5	mg/ L
Pond #3	V_3 =	3,121,613	gallons
	Q =	570,000	gpd
	k_L =	0.19	d^{-1}
	t =	5.48	days
	C_2 =	118.5	mg/ L
	C_3 =	57.8	mg/ L
Pond #4	V_4 =	3,121,613	gallons
	Q =	570,000	gpd
	k_L =	0.19	d^{-1}
	t =	5.48	days
	C_3 =	57.8	mg/ L
	C_4 =	**28.2**	**mg/ L**

total retention time = **18.71**

% reduction = **92%**

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Four Ponds in Series - Summer Season (High temp & high flow condition)

Pond #1	V_1 =	2,211,984	gallons
	Q =	638,000	gpd
	k_H =	0.30	d^{-1}
	t =	3.47	days
	C_o =	360	mg/L
	C_1 =	177.8	mg/ L
Pond #2	V_2 =	2,211,984	gallons
	Q =	638,000	gpd
	k_H =	0.30	d^{-1}
	t =	3.47	days
	C_1 =	177.8	mg/ L
	C_2 =	87.8	mg/ L
Pond #3	V_3 =	3,121,613	gallons
	Q =	638,000	gpd
	k_H =	0.30	d^{-1}
	t =	4.89	days
	C_2 =	87.8	mg/ L
	C_3 =	35.9	mg/ L
Pond #4	V_4 =	3,121,613	gallons
	Q =	638,000	gpd
	k_H =	0.30	d^{-1}
	t =	4.89	days
	C_3 =	35.9	mg/ L
	C_4 =	**14.7**	**mg/ L**

total retention time = **16.72**

% reduction = **96%**

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Four Ponds in Series - MMF Summer Season (High temp & MMF flow condition)

Pond #1	V_1 =	2,211,984	gallons
	Q =	900,000	gpd
	k_H =	0.30	d^{-1}
	t =	2.46	days
	C_o =	360	mg/L
	C_1 =	208.5	mg/ L
Pond #2	V_2 =	2,211,984	gallons
	Q =	900,000	gpd
	k_H =	0.30	d^{-1}
	t =	2.46	days
	C_1 =	208.5	mg/ L
	C_2 =	120.8	mg/ L
Pond #3	V_3 =	3,121,613	gallons
	Q =	900,000	gpd
	k_H =	0.30	d^{-1}
	t =	3.47	days
	C_2 =	120.8	mg/ L
	C_3 =	59.6	mg/ L
Pond #4	V_4 =	3,121,613	gallons
	Q =	900,000	gpd
	k_H =	0.30	d^{-1}
	t =	3.47	days
	C_3 =	59.6	mg/ L
	C_4 =	**29.4**	**mg/ L**

total retention time = **11.85**

% reduction = **92%**

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ENGINEERS, SURVEYORS, PLANNERS

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Two Ponds in Series, Two parallel flow trains - Winter Season (Low temp & low flow condition)

Pond #1	V_1 =	2,211,984	gallons
	Q =	285,000	gpd
	k_L =	0.19	d^{-1}
	t =	7.76	days
	C_o =	360	mg/L
	C_1 =	144.8	mg/ L
Pond #4	V_3 =	3,121,613	gallons
	Q =	285,000	gpd
	k_L =	0.19	d^{-1}
	t =	10.95	days
	C_1 =	144.8	mg/ L
	C_3 =	**46.7**	**mg/ L**
Pond #2	V_2 =	2,211,984	gallons
	Q =	285,000	gpd
	k_L =	0.19	d^{-1}
	t =	7.76	days
	C_o =	360	mg/L
	C_2 =	144.8	mg/ L
Pond #3	V_4 =	3,121,613	gallons
	Q =	285,000	gpd
	k_L =	0.19	d^{-1}
	t =	10.95	days
	C_2 =	144.8	mg/ L
	C_4 =	**46.7**	**mg/ L**

total retention time = **18.71**

% reduction = **87%**

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ENGINEERS, SURVEYORS, PLANNERS

BY:	EKS	**DATE:**	11/17/2008	**SUBJECT:**	SOUTHLAND WWTF	**JOB NO.**	19996.17
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Two Ponds in Series, Two parallel flow trains - Summer Season (High temp & high flow condition)

Pond #1	V_1 =	2,211,984	gallons
	Q =	319,000	gpd
	k_H =	0.30	d^{-1}
	t =	6.93	days
	C_o =	360	mg/L
	C_1 =	118.0	mg/ L
Pond #4	V_3 =	3,121,613	gallons
	Q =	319,000	gpd
	k_H =	0.30	d^{-1}
	t =	9.79	days
	C_1 =	118.0	mg/ L
	C_3 =	**30.3**	**mg/ L**
Pond #2	V_2 =	2,211,984	gallons
	Q =	319,000	gpd
	k_H =	0.30	d^{-1}
	t =	6.93	days
	C_o =	360	mg/L
	C_2 =	118.0	mg/ L
Pond #3	V_4 =	3,121,613	gallons
	Q =	319,000	gpd
	k_H =	0.30	d^{-1}
	t =	9.79	days
	C_2 =	118.0	mg/ L
	C_4 =	**30.3**	**mg/ L**

total retention time = **16.72**

% reduction = **92%**

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BY: EKS **DATE:** 11/17/2008 **SUBJECT:** SOUTHLAND WWTF **JOB NO.** 19996.17

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Two Ponds in Series, Two parallel flow trains - MMF Summer Season (High temp & MMF flow cond.)

Pond #1	V_1 =	2,211,984	gallons
	Q =	450,000	gpd
	k_H =	0.30	d^{-1}
	t =	4.92	days
	C_o =	360	mg/L
	C_1 =	146.7	mg/ L
Pond #4	V_3 =	3,121,613	gallons
	Q =	450,000	gpd
	k_H =	0.30	d^{-1}
	t =	6.94	days
	C_1 =	146.7	mg/ L
	C_3 =	**48.1**	**mg/ L**
Pond #2	V_2 =	2,211,984	gallons
	Q =	450,000	gpd
	k_H =	0.30	d^{-1}
	t =	4.92	days
	C_o =	360	mg/L
	C_2 =	146.7	mg/ L
Pond #3	V_4 =	3,121,613	gallons
	Q =	450,000	gpd
	k_H =	0.30	d^{-1}
	t =	6.94	days
	C_2 =	146.7	mg/ L
	C_4 =	**48.1**	**mg/ L**

total retention time = **11.85**

% reduction = **87%**

*M&E Reference: Wastewater Engineering Treatment and Reuse, 4th Edition

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BY: EKS **DATE:** 11/17/2008 **SUBJECT:** SOUTHLAND WWTF **JOB NO.** 19996.17

CHKD. BY: ______ **DATE:** ______ TREATMENT CAPACITY FOR FUTURE FLOWS

BOD Removal in Ponds

$$\frac{C_n}{C_o} = \frac{1}{1+(k/nt)^n}$$ First order for *n* equally sized lagoons in series (ref. M&E p 843)

$$C = \frac{C_o}{1+(kV/Q)}$$ First order for each lagoon with unique volume and/ or removal rate (ref. M&E p 843)

Effluent BOD_5 Goal

C = 80 mg/L* (conserv. assumption of 80% of eff. Limitation)

Inffluent BOD_5

C_o = 360 mg/ L (Dec 05 - Aug 06 90th percentile BOD_5)

Estimated Inf. BOD_u = 529.2 mg/ L (inf. BOD_5 x 1.47)

$k_T = k_{20}(1.036)^{T-20}$

k_{20} =	0.276	d^{-1} (first-order rate constant at 20°C)		
T_L =	49.4	°F (Approximate ground temp., Dec)		
=	9.7	°C	=	282.8 °K
T_H =	71.5	°F (Approximate ground temp., July)		
=	21.9	°C	=	295.1 °K
k_L =	0.19	d^{-1}		
k_H =	0.30	d^{-1}		

Flows (projected for 2030)

PDF	3.34	mgd	= Q_H
AAF	1.67	mgd	= Q_L
MMF	2.24	mgd	= Q_{MMF}

Volumes

Primary	=	295,700	ft^3
	=	2,211,984	gallons
Secondary	=	417,300	ft^3 (total volume available for aeration)
	=	3,121,613	gallons

Aeration requirement (oxygen demand)

O_2 demand (lb/ day) = Co x 1.5 x Q_{Ave} x 8.34e-6 Note: 1mg/L = 8.34e-6 lb/gal;

Calculated oxygen demands

Cu = 540 mg/ L (1.5 x Co)

Q_L = 1,670,000 gpd
Q_H = 3,340,000 gpd
Q_{MMF} = 2,237,800 gpd

Oxygen demand for low flow rate: **7,521.0 lb O_2/ day**
Oxygen demand for high flow rate: **15,042.0 lb O_2/ day**
Oxygen demand for permit MMFflow rate: **10,078.2 lb O_2/ day**

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BY: EKS **DATE:** 11/17/2008 **SUBJECT:** SOUTHLAND WWTF **JOB NO.** 19996.17

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Current System Aeration Capacity

Calculate actual oxygen transfer rate for low-speed surface aerators

$$N = N_o \times \frac{B\,C_W - C_l}{C_{S\,20}} \times 1.024^{T-20} \times a$$

N_o =	2.5	lb O_2/ HP.hr (O_2 transferred under std. cond. for low-speed surface)
B =	1	(salinity-surface tension factor, typically 1)
$C_{W\,L}$ =	11.0	mg/ L (oxygen saturation concentration at temp 9.7C and 300 ft, M&E)
$C_{W\,H}$ =	8.5	mg/ L (oxygen saturation concentration at temp 21.9C and 300 ft, M&E)
C_l =	2.0	mg/ L (operating oxygen concentration)
$C_{S\,20}$ =	9.08	mg/ L (oxygen saturation concentration at temp 20C)
T_L =	49.4	^oF (Approximate ground temp., Dec)
=	9.7	^oC
T_H =	71.5	^oF (Approximate ground temp., July)
=	21.9	^oC
a =	0.82	oxygen transfer correction factor for municipal wastewater
N_L =	**1.95**	**lb O_2/ HP.hr (low temp)**
N_H =	**2.01**	**lb O_2/ HP.hr (high temp)**
Available HP =	110	HP
$AOTR_L$ =	**5140.8**	**lb O_2/ day (low temp)**
$AOTR_H$ =	**5295.8**	**lb O_2/ day (high temp)**

Calculate amount of horsepower required to satisfy oxygen demand

Oxygen demand for low flow rate:	7,521.0	lb O_2/ day
Oxygen demand for high flow rate:	15,042.0	lb O_2/ day
Oxygen demand for max month flow rate:	10,078.2	lb O_2/ day

N_L =	1.95	lb O_2/ HP.hr (low temp)
N_H =	2.01	lb O_2/ HP.hr (high temp)

For high flow rate

Total HP =	**315.0**	**HP**
$AOTR_L$ =	**14721.3**	**lb O_2/ day (low temp)**
$AOTR_H$ =	**15165.2**	**lb O_2/ day (high temp)**

For max month flow rate

Total HP =	**210.0**	**HP**
$AOTR_L$ =	**9814.2**	**lb O_2/ day (low temp)**
$AOTR_H$ =	**10110.1**	**lb O_2/ day (high temp)**

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CHKD. BY:		**DATE:**	TREATMENT CAPACITY FOR FUTURE FLOWS		

Ponds in Series - Winter Season (Low temp & low flow condition)

Current System Under 2030 Flow Conditions

Pond #1	V_1 =	2,211,984	gallons
	Q =	1,670,000	gpd
	k_L =	0.19	d^{-1}
	t =	1.32	days
	C_o =	360	mg/L
	C_1 =	287.2	mg/ L
Pond #2	V_2 =	2,211,984	gallons
	Q =	1,670,000	gpd
	k_L =	0.19	d^{-1}
	t =	1.32	days
	C_1 =	287.2	mg/ L
	C_2 =	229.1	mg/ L
Pond #3	V_3 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_L =	0.19	d^{-1}
	t =	1.87	days
	C_2 =	229.1	mg/ L
	C_3 =	168.7	mg/ L
Pond #4	V_4 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_L =	0.19	d^{-1}
	t =	1.87	days
	C_3 =	168.7	mg/ L
	C_4 =	**124.2**	**mg/ L**

current % reduction = **65%** total retention time = **6.39** days

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Ponds in Series - Winter Season (Low temp & low flow condition)

Add two ponds, V = 3,121,613 gallons each

Pond #1	V_1 =	2,211,984	gallons
	Q =	1,670,000	gpd
	k_L =	0.19	d^{-1}
	t =	1.32	days
	C_o =	360	mg/L
	C_1 =	287.2	mg/ L
Pond #2	V_2 =	2,211,984	gallons
	Q =	1,670,000	gpd
	k_L =	0.19	d^{-1}
	t =	1.32	days
	C_1 =	287.2	mg/ L
	C_2 =	229.1	mg/ L
Pond #3	V_3 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_L =	0.19	d^{-1}
	t =	1.87	days
	C_2 =	229.1	mg/ L
	C_3 =	168.7	mg/ L
Pond #4	V_4 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_L =	0.19	d^{-1}
	t =	1.87	days
	C_3 =	168.7	mg/ L
	C_4 =	**124.2**	**mg/ L**
New Pond 5	V_5 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_L =	0.19	d^{-1}
	t =	1.87	days
	C_4 =	124.2	mg/ L
	C_5 =	**91.5**	**mg/ L**
New Pond 6	V_6 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_L =	0.19	d^{-1}
	t =	1.87	days
	C_5 =	91.5	mg/ L
	C_6 =	**67.4**	**mg/ L**

% reduction **81%** total retention time = **10.13 days**

For ponds in series,
Two additional ponds would treat the wastewater to acceptable levels during low temp, low flow conditions

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BY:	EKS	**DATE:**	11/17/2008	**SUBJECT:**	SOUTHLAND WWTF	**JOB NO.**	19996.17
CHKD. BY:		**DATE:**			TREATMENT CAPACITY FOR FUTURE FLOWS		

Ponds in Series - Summer Season (High temp & high flow condition)

Current System Under 2030 Flow Conditions

Pond #1	V_1 =	2,211,984	gallons			
	Q =	3,340,000	gpd			
	k_H =	0.30	d^{-1}			
	t =	0.66	days			
	C_o =	360	mg/L			
	C_1 =	301.1	mg/ L			
Pond #2	V_2 =	2,211,984	gallons			
	Q =	3,340,000	gpd			
	k_H =	0.30	d^{-1}			
	t =	0.66	days			
	C_1 =	301.1	mg/ L			
	C_2 =	251.8	mg/ L			
Pond #3	V_3 =	3,121,613	gallons			
	Q =	3,340,000	gpd			
	k_H =	0.30	d^{-1}			
	t =	0.93	days			
	C_2 =	251.8	mg/ L			
	C_3 =	197.3	mg/ L			
Pond #4	V_4 =	3,121,613	gallons			
	Q =	3,340,000	gpd			
	k_H =	0.30	d^{-1}			
	t =	0.93	days			
	C_3 =	197.3	mg/ L			
	C_4 =	**154.5**	**mg/ L**	total retention time =	**3.19**	**days**
	% reduction =	**57%**				

Ponds in Series - Summer Season (High temp & high flow condition)

Add two ponds, V = 3,121,613 gallons each

Pond #1	V_1 =	2,211,984	gallons
	Q =	3,340,000	gpd
	k_H =	0.30	d^{-1}
	t =	0.66	days
	C_o =	360	mg/L
	C_1 =	301.1	mg/ L
Pond #2	V_2 =	2,211,984	gallons
	Q =	3,340,000	gpd
	k_H =	0.30	d^{-1}
	t =	0.66	days
	C_1 =	301.1	mg/ L
	C_2 =	251.8	mg/ L
Pond #3	V_3 =	3,121,613	gallons
	Q =	3,340,000	gpd
	k_H =	0.30	d^{-1}
	t =	0.93	days
	C_2 =	251.8	mg/ L
	C_3 =	197.3	mg/ L
Pond #4	V_4 =	3,121,613	gallons
	Q =	3,340,000	gpd
	k_H =	0.30	d^{-1}
	t =	0.93	days
	C_3 =	197.3	mg/ L
	C_4 =	**154.5**	**mg/ L**
New Pond 5	V_5 =	3,121,613	gallons
	Q =	3,340,000	gpd
	k_H =	0.30	d^{-1}
	t =	0.93	days
	C_4 =	154.5	mg/ L
	C_5 =	**121.1**	**mg/ L**
New Pond 6	V_6 =	3,121,613	gallons
	Q =	3,340,000	gpd
	k_H =	0.30	d^{-1}
	t =	0.93	days
	C_5 =	121.1	mg/ L
	C_6 =	**94.9**	**mg/ L**

total retention time = **5.06 days**

Two ponds don't reach effluent goal, try additional pond:

New Pond 7	V_7 =	3,121,613	gallons
	Q =	3,340,000	gpd
	k_H =	0.30	d^{-1}
	t =	0.93	days
	C_6 =	94.9	mg/ L
	C_7 =	**74.3**	**mg/ L**

% reduction = **79%**

total retention time = **6.00 days**

For ponds in series,
Three additional ponds would treat the wastewater to acceptable levels during high temp, high flow conditions

BOYLE ENGINEERING

ENGINEERS, SURVEYORS, PLANNERS

BY:	EKS	**DATE:**	11/17/2008	**SUBJECT:**	SOUTHLAND WWTF	**JOB NO.**	19996.17
CHKD. BY:		**DATE:**			TREATMENT CAPACITY FOR FUTURE FLOWS		

Ponds in Series - MMF Summer Season (High temp & MMF flow condition)

Current System Under 2030 Flow Conditions

Pond #1	V_1 =	2,211,984	gallons			
	Q =	2,237,800	gpd			
	k_H =	0.30	d^{-1}			
	t =	0.99	days			
	C_o =	360	mg/L			
	C_1 =	278.6	mg/ L			
Pond #2	V_2 =	2,211,984	gallons			
	Q =	2,237,800	gpd			
	k_H =	0.30	d^{-1}			
	t =	0.99	days			
	C_1 =	278.6	mg/ L			
	C_2 =	215.6	mg/ L			
Pond #3	V_3 =	3,121,613	gallons			
	Q =	2,237,800	gpd			
	k_H =	0.30	d^{-1}			
	t =	1.39	days			
	C_2 =	215.6	mg/ L			
	C_3 =	152.6	mg/ L			
Pond #4	V_4 =	3,121,613	gallons			
	Q =	2,237,800	gpd			
	k_H =	0.30	d^{-1}			
	t =	1.39	days			
	C_3 =	152.6	mg/ L			
	C_4 =	**108.1**	**mg/ L**	total retention time =	**4.77**	**days**
	% reduction =	**70%**				

BOYLE ENGINEERING

ENGINEERS, SURVEYORS, PLANNERS

BY:	EKS	**DATE:**	11/17/2008	**SUBJECT:**	SOUTHLAND WWTF	**JOB NO.**	19996.17
CHKD. BY:		**DATE:**			TREATMENT CAPACITY FOR FUTURE FLOWS		

Ponds in Series - MMF Summer Season (High temp & MMF flow condition)

Add ponds V = 3,121,613 gallons

Pond #1	V_1 =	2,211,984	gallons
	Q =	2,237,800	gpd
	k_H =	0.30	d^{-1}
	t =	0.99	days
	C_o =	360	mg/L
	C_1 =	278.6	mg/ L
Pond #2	V_2 =	2,211,984	gallons
	Q =	2,237,800	gpd
	k_H =	0.30	d^{-1}
	t =	0.99	days
	C_1 =	278.6	mg/ L
	C_2 =	215.6	mg/ L
Pond #3	V_3 =	3,121,613	gallons
	Q =	2,237,800	gpd
	k_H =	0.30	d^{-1}
	t =	1.39	days
	C_2 =	215.6	mg/ L
	C_3 =	152.6	mg/ L
Pond #4	V_4 =	3,121,613	gallons
	Q =	2,237,800	gpd
	k_H =	0.30	d^{-1}
	t =	1.39	days
	C_3 =	152.6	mg/ L
	C_4 =	**108.1**	**mg/ L**
New Pond 5	V_5 =	3,121,613	gallons
	Q =	2,237,800	gpd
	k_H =	0.30	d^{-1}
	t =	1.39	days
	C_4 =	108.1	mg/ L
	C_5 =	**76.5**	**mg/ L**
	% reduction =	**79%**	

total retention time = **6.16 days**

For ponds in series,

One additional pond would treat the wastewater to acceptable levels during high temp, max month flow conditions

BOYLE ENGINEERING

ENGINEERS, SURVEYORS, PLANNERS

BY:	EKS	**DATE:**	11/17/2008	**SUBJECT:**	SOUTHLAND WWTF	**JOB NO.**	19996.17
CHKD. BY:		**DATE:**			TREATMENT CAPACITY FOR FUTURE FLOWS		

Two parallel flow trains - Winter Season (Low temp & low flow condition)

Current System Under 2030 Flow Conditions

Pond #1	V_1 =	2,211,984	gallons			
	Q =	835,000	gpd			
	k_L =	0.19	d^{-1}			
	t =	2.65	days			
	C_o =	360	mg/L			
	C_1 =	238.8	mg/ L			
Pond #4	V_4 =	3,121,613	gallons			
	Q =	835,000	gpd			
	k_L =	0.19	d^{-1}			
	t =	3.74	days			
	C_1 =	238.8	mg/ L			
	C_4 =	**139.2**	**mg/ L**			
Pond #2	V_2 =	2,211,984	gallons			
	Q =	835,000	gpd			
	k_L =	0.19	d^{-1}			
	t =	2.65	days			
	C_o =	360	mg/L			
	C_2 =	238.8	mg/ L			
Pond #3	V_3 =	3,121,613	gallons			
	Q =	835,000	gpd			
	k_L =	0.19	d^{-1}			
	t =	3.74	days			
	C_2 =	238.8	mg/ L			
	C_3 =	**139.2**	**mg/ L**	total retention time =	**6.39**	**days**
	% reduction =	**61%**				

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ENGINEERS, SURVEYORS, PLANNERS

BY: EKS **DATE:** 11/17/2008 **SUBJECT:** SOUTHLAND WWTF **JOB NO.** 19996.17
CHKD. BY: **DATE:** TREATMENT CAPACITY FOR FUTURE FLOWS

Two parallel flow trains - Winter Season (Low temp & low flow condition)

Add two ponds, V = 3,121,613 gallons each

Pond #1	V_1 =	2,211,984	gallons
	Q =	835,000	gpd
	k_L =	0.19	d^{-1}
	t =	2.65	days
	C_o =	360	mg/L
	C_1 =	238.8	mg/ L
Pond #4	V_4 =	3,121,613	gallons
	Q =	835,000	gpd
	k_L =	0.19	d^{-1}
	t =	3.74	days
	C_1 =	238.8	mg/ L
	C_4 =	**139.2**	**mg/ L**
New Pond 5	V_5 =	3,121,613	gallons
	Q =	835,000	gpd
	k_L =	0.19	d^{-1}
	t =	3.74	days
	C_4 =	139.2	mg/ L
	C_5 =	**81.1**	**mg/ L**
Pond #2	V_2 =	2,211,984	gallons
	Q =	835,000	gpd
	k_L =	0.19	d^{-1}
	t =	2.65	days
	C_o =	360	mg/L
	C_2 =	238.8	mg/ L
Pond #3	V_3 =	3,121,613	gallons
	Q =	835,000	gpd
	k_L =	0.19	d^{-1}
	t =	3.74	days
	C_2 =	238.8	mg/ L
	C_3 =	**139.2**	**mg/ L**
New Pond 6	V_6 =	3,121,613	gallons
	Q =	835,000	gpd
	k_L =	0.19	d^{-1}
	t =	3.74	days
	C_3 =	139.2	mg/ L
	C_6 =	**81.1**	**mg/ L**

total retention time = **10.13 days**

% reduction = **77%**

For two parallel flow trains,
Two additional ponds would treat the wastewater to acceptable levels during low temp, low flow conditions

Two parallel flow trains - Summer Season (High temp & high flow condition)

Current System Under 2030 Flow Conditions

Pond #1	V_1 =	2,211,984	gallons
	Q =	1,670,000	gpd
	k_H =	0.30	d^{-1}
	t =	1.32	days
	C_o =	360	mg/L
	C_1 =	258.7	mg/ L
Pond #4	V_3 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_H =	0.30	d^{-1}
	t =	1.87	days
	C_1 =	258.7	mg/ L
	C_3 =	**166.6**	**mg/ L**
Pond #2	V_2 =	2,211,984	gallons
	Q =	1,670,000	gpd
	k_H =	0.30	d^{-1}
	t =	1.32	days
	C_o =	360	mg/L
	C_2 =	258.7	mg/ L
Pond #3	V_4 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_H =	0.30	d^{-1}
	t =	1.87	days
	C_2 =	258.7	mg/ L
	C_4 =	**166.6**	**mg/ L**
	% reduction =	**54%**	

total retention time = **3.19 days**

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ENGINEERS, SURVEYORS, PLANNERS

BY:	EKS	**DATE:**	11/17/2008	**SUBJECT:**	SOUTHLAND WWTF	**JOB NO.**	19996.17
CHKD. BY:		**DATE:**			TREATMENT CAPACITY FOR FUTURE FLOWS		

Two parallel flow trains - Summer Season (High temp & high flow condition)

Add four ponds, V = 3,121,613 gallons each

Pond #1	V_1 =	2,211,984	gallons
	Q =	1,670,000	gpd
	k_H =	0.30	d^{-1}
	t =	1.32	days
	C_o =	360	mg/L
	C_1 =	258.7	mg/ L
Pond #4	V_3 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_H =	0.30	d^{-1}
	t =	1.87	days
	C_1 =	258.7	mg/ L
	C_3 =	166.6	mg/ L
New Pond 1	V_3 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_H =	0.30	d^{-1}
	t =	1.87	days
	C_3 =	166.6	mg/ L
	C_5 =	**107.3**	**mg/ L**
New Pond 2	V_3 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_H =	0.30	d^{-1}
	t =	1.87	days
	C_5 =	107.3	mg/ L
	C_7 =	**69.1**	**mg/ L**
Pond #2	V_2 =	2,211,984	gallons
	Q =	1,670,000	gpd
	k_H =	0.30	d^{-1}
	t =	1.32	days
	C_o =	360	mg/L
	C_2 =	258.7	mg/ L
Pond #3	V_4 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_H =	0.30	d^{-1}
	t =	1.87	days
	C_2 =	258.7	mg/ L
	C_4 =	166.6	mg/ L
New Pond 3	V_3 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_H =	0.30	d^{-1}
	t =	1.87	days
	C_4 =	166.6	mg/ L
	C_6 =	**107.3**	**mg/ L**
New Pond 4	V_3 =	3,121,613	gallons
	Q =	1,670,000	gpd
	k_H =	0.30	d^{-1}
	t =	1.87	days
	C_6 =	107.3	mg/ L
	C_8 =	**69.1**	**mg/ L**

total retention time = **6.93 days**

% reduction = **81%**

For two parallel flow trains,
Four additional ponds are needed treat the wastewater to acceptable levels during high temp, high flow conditions

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ENGINEERS, SURVEYORS, PLANNERS

BY:	EKS	**DATE:**	11/17/2008	**SUBJECT:**	SOUTHLAND WWTF	**JOB NO.**	19996.17
CHKD. BY:		**DATE:**			TREATMENT CAPACITY FOR FUTURE FLOWS		

Two parallel flow trains - MMF Summer Season (High temp & MMF flow cond.)

Current System Under 2030 Flow Conditions

Pond #1	V_1 =	2,211,984	gallons
	Q =	1,118,900	gpd
	k_H =	0.30	d^{-1}
	t =	1.98	days
	C_o =	360	mg/L
	C_1 =	227.2	mg/ L
Pond #4	V_3 =	3,121,613	gallons
	Q =	1,118,900	gpd
	k_H =	0.30	d^{-1}
	t =	2.79	days
	C_1 =	227.2	mg/ L
	C_3 =	**124.5**	**mg/ L**
Pond #2	V_2 =	2,211,984	gallons
	Q =	1,118,900	gpd
	k_H =	0.30	d^{-1}
	t =	1.98	days
	C_o =	360	mg/L
	C_2 =	227.2	mg/ L
Pond #3	V_4 =	3,121,613	gallons
	Q =	1,118,900	gpd
	k_H =	0.30	d^{-1}
	t =	2.79	days
	C_2 =	227.2	mg/ L
	C_4 =	**124.5**	**mg/ L**
	% reduction =	**65%**	

total retention time = **4.77 days**

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ENGINEERS, SURVEYORS, PLANNERS

BY:	EKS	**DATE:**	11/17/2008	**SUBJECT:**	SOUTHLAND WWTF	**JOB NO.**	19996.17
CHKD. BY:		**DATE:**			TREATMENT CAPACITY FOR FUTURE FLOWS		

Three Ponds in Series, Two parallel flow trains - MMF Summer Season (High temp & MMF flow cond.)

Add two ponds, V = 3,121,613 gallons each

Pond #1	V_1 =	2,211,984	gallons
	Q =	1,118,900	gpd
	k_H =	0.30	d^{-1}
	t =	1.98	days
	C_o =	360	mg/L
	C_1 =	227.2	mg/ L
Pond #4	V_3 =	3,121,613	gallons
	Q =	1,118,900	gpd
	k_H =	0.30	d^{-1}
	t =	2.79	days
	C_1 =	227.2	mg/ L
	C_3 =	124.5	mg/ L
New Pond	V_3 =	3,121,613	gallons
	Q =	1,118,900	gpd
	k_H =	0.30	d^{-1}
	t =	2.79	days
	C_3 =	124.5	mg/ L
	C_5 =	**68.2**	**mg/ L**
Pond #2	V_2 =	2,211,984	gallons
	Q =	1,118,900	gpd
	k_H =	0.30	d^{-1}
	t =	1.98	days
	C_o =	360	mg/L
	C_2 =	227.2	mg/ L
Pond #3	V_4 =	3,121,613	gallons
	Q =	1,118,900	gpd
	k_H =	0.30	d^{-1}
	t =	2.79	days
	C_2 =	227.2	mg/ L
	C_4 =	124.5	mg/ L
New Pond	V_3 =	3,121,613	gallons
	Q =	1,118,900	gpd
	k_H =	0.30	d^{-1}
	t =	2.79	days
	C_4 =	124.5	mg/ L
	C_6 =	**68.2**	**mg/ L**

total retention time = **7.56 days**

% reduction = **81%**

For two parallel flow trains,
Two additional ponds would treat the wastewater to acceptable levels during high temp, max month flow conditions

*M&E Reference: Wastewater Engineering Treatment and Reuse, 4th Edition

Boyle Engineering Corporation

BY: EKM **DATE:** 12/1/2006 **SUBJECT** Southland WWTF Master Plan **JOB NO:** 19996.17
CHKD. BY: **DATE:** Future Projected Solids Production (2030)

Determine: Volume of solids added to ponds over 5 years at projected 2030 flowrate.

Assumptions:

AAF = 1.67 mgd Average TSSin = 265 mg/L Average TSSout = 40 mg/L

1) Total volume of wastewater treated in past 5 years

V = Q x t

V = 1.67 mgd x 5 yrs x 365 days/yr

V = 3048 Mgal

2) Mass of TSS removed

Mass = (TSS_{in} - TSS_{out}) x V x (8.34 lb/Mgal x mg/L)

Mass = (265 - 40) x (13048) x (8.34)

= 5,719,103 lbs

= 1,143,821 lbs/yr

3) Mass of volatile and fixed solids

$Mass_{VSS}$ = 0.70 x TSS

= 0.70 x (2,054,768)

= 4,003,372 lbs

= 800,674 lbs/yr

$Mass_{Fixed}$ = $Mass_{TSS}$ - $Mass_{VSS}$

= 2,054,768 - 1,438,337

= 1,715,731 lbs

= 343,146 lbs/yr

4) Amount of accumulation at the end of 5 years

Assume 60% VSS reduction occurs within 1 year

$(VSS)_t$ = [0.7 + 0.4(t-1)] x VSS

= [0.7 + 0.4(5-1)] x 489,166

= 1,841,551 lbs

5) Total mass of solids

$Mass_{Total}$ = $Mass_{Fixed}$ + $Mass_{Accumulated}$

= 1,048,213 + 1,125,082

= 3,557,282 lbs

6) Volume of solids (assume 15% solids and density = 1.06*8.34 lb/gal)

V_{Total} = $Mass_{Total}$ / (0.15*density)

= 2,682,595 gal

Boyle Engineering Corporation

BY: EKM **DATE:** 12/1/2006 **SUBJECT** Southland WWTF Master Plan **JOB NO:** 19996.17
CHKD. BY: **DATE:** Future Projected Solids Production (2030)

Potential percentage of solid volume in ponds over 5 years at projected flowrate

Total pond volume (taken from NCSD Southland O&M Manual, July 2000)
Liquid volume = 2 @ 295,700 cf & 2 @ 417,300 cf
Sludge volume = 2 @ 0.5 Mgal & 2 @ 0.7 Mgal

V_{Total} = [2 x 295,700 + 2 x 417,300] x 7.481 gal/cf + 2 x 500,000 + 2 x 700, 000
V_{Total} = 13,067,906 gal

% of solids in pond = $\frac{2,682,595}{13,067,906}$

= 0.21
= 21% of existing pond volume for 5 years at projected future flowrate